983,073

PATENT SPECIFICATION

DRAWINGS ATTACHED

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COMPLETE SPECIFICATION

Absorbable Hemostat

We, JOHNSON & JOHNSON, a Corporation organised under the laws of the State of New Jersey, United States of America, of 501 George Street, New Brunswick, New Jersey, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to an absorbable hemostatic agent in fiber form, and more particularly to oxidized regenerated cellulose fabrics and fibrous masses having special characteristics for surgical purposes.

Absorbable hemostatic materials are used to control bleeding associated with surgery, where other methods such as suturing are impracticable. Such materials are designed to be absorbed in the body tissues when left in situ. It is important that such materials be absorbed or assimilated at a uniform and dependable rate and function with a high degree of hemostatic activity.

Oxidized cellulose prepared from cotton has been used for such purposes. However, it has many drawbacks, especially non-uniformity and relatively poor shelf-life. The art is confronted by the problem of providing such materials having adequate and reliable uniformity and good shelf-life.

The discoveries associated with the invention and relating to the solution of the above problems, and the objects achieved in accordance with the invention as set forth herein include: the provision of stable and uniformly absorbable hemostatic fabrics and frictionally interlocked fibrous masses such as formed of carded and needled fibers in which the fiber of the fabrics or fibrous masses is formed of oxidized regenerated cellulose which prior to oxidation has a degree of polymerization (D.P.) of not appreciably over 400 glucose units and in which the filament denier is within the range of about 1 to 9 or preferably 1 to 3 the oxidized regenerated cellulose containing about 12 to 25 or preferably 18 to 22 per cent COOH radical by weight; the fabrics are preferably knitted and contain about 12 to 30 courses and 12 to 30 wales to the linear inch of about 150 denier multi-filament yarn; the provision of a process for preparing fabrics, fibrous masses, threads, strands, sutures, knit or woven tubes or articles composed of mixtures of threads of different kinds, which process comprises reacting the fabric, fibrous mass or the like of regenerated cellulose of a D.P. not over about 400 glucose units with a solution of dinitrogen tetroxide (N_2O_4) in trichlorotrifluoroethane containing about 20 per cent by weight of dinitrogen tetroxide of a temperature of between 20°C—28°C, e.g. about 24°C for a time of between 14 and 18 hours, e.g. about 16 hours, washing with carbon tetrachloride and/or trichlorotrifluoroethane ($CCl_2F—CClF_2$) until the fabric is substantially free of dinitrogen tetroxide and then washing with 50 per cent aqueous isopropyl alcohol, followed by washing with about 99 per cent isopropyl alcohol to remove the water, and drying at room temperature; the provision of such a process followed by enclosing the product in a container impervious to microorganisms but pervious to vapours, and further followed by subjecting same to heat and sterilizing vapours such as formaldehyde vapours or mixtures of ethylene oxide and carbon dioxide vapors until sterilized; and other objects which will be apparent as details or embodiments of the invention are set forth hereinafter, and in the accompanying drawings.

In the drawings, Figure 1 is a view of a knitted fabric and Figure 2 is a much enlarged fragmental view thereof, whereas Figure 3 is an enlarged view of a pledget of a fibrous mass made of oxidized carded, crimped, regenerated cellulose staple fiber.

Figure 1 is a view of the fabric 10 made of oxidized regenerated cellulose, and Figure

2 is a much enlarged fragmental view of this fabric 10 showing the filaments 14 and the yarns 12 in the knitted structure.

In Figure 3 the pledget 15 is made of oxidized carded, crimped, regenerated cellulose staple fiber 16.

In order to facilitate a clear understanding of the invention, the following preferred specific embodiments are described in detail.

EXAMPLE I

The starting material is a plain jersey construction of knitted rayon fabric containing approximately 13 square yards per pound, and showing a count of 18 courses and 18 wales to the linear inch. It is knit on a Wildman 28 cut spring needle knitting machine using 150 denier, 90 filament bright rayon yarn, (the filament denier being 1.6). The diameter of the filament is uniform. It is made by the viscose process and is of high purity, being substantially free of titanium oxide or any other metals or compounds of metals.

This material is fastened to a perforated tubular core and wound loosely around the core. The fabric and core are secured in place in a glass or glass-lined reactor. The trichlorotrifluoroethane is charged into the reactor, and a circulating pump is employed to circulate the fluid through the core and the fabric. Sufficient dinitrogen tetroxide is then added to the liquid to bring the dinitrogen tetroxide content up to 20 per cent by weight of the liquid. The temperature of the liquid mixture is maintained at approximately 24°C. and the pumping continued for 15½ hours.

Then the reaction is terminated by draining the reaction liquor from the reaction vessel and covering the oxidized fabric with carbon tetrachloride. The carbon tetrachloride is circulated through the fabric for 15 minutes and drained. Fresh carbon tetrachloride is then added and the fabric treated in similar fashion two more times. After the carbon tetrachloride washes have removed the bulk of the dinitrogen tetroxide, a 50 per cent water, isopropyl alcohol solution is added and pumped through the fabric, followed in similar manner to the carbon tetrachloride washes by two fresh washes of the same isopropyl alcohol mixture. Two final washes of 99 per cent isopropyl alcohol are then used to remove traces of water. The fabric is dried in a forced air oven at room temperature. If desired, a trichlorotrifluoroethane wash may be used in place of the carbon tetrachloride.

After drying, the material is cut into appropriate sizes, packaged (e.g., in a container which is impervious to microorganisms, but pervious to the sterilizing agent, or one which is partly open and is closed after the sterilization step), and sterilized by heat and formaldehyde vapors.

A vacuum is drawn on the sterilizer and a temperature of 135°F. is maintained. A solution of 90 parts of U.S.P. Formaldehyde Solution and 10 parts glycerin is heated in a connecting generator. This is introduced into the sterilizer up to a sterilizing dose level. During the introduction the temperature of the load rises and is maintained at 160°F. for one hour. The sterilizer is then evacuated and the sterilized packages are removed.

The resulting product is of high purity as shown by the following chemical analysis:

% CH_2O	0.36
% COOH	19.1—20.3
% N_2	0.24
% Ash	0.145
Total Heavy Metals	7.5 parts per million

The hemostatic activity of the product is about 2 minutes 30 seconds. This is well below the usual standard of about 6 minutes. Corresponding results are obtained in clinical use. This hemostatic activity is determined by the following procedure. The spleens of four dogs are anesthetized with sodium pentobarbital (33 mg/Kgm) and are employed as the test sites for these studies. Multiple tests are carried out on each spleen as follows: criss-cross incised wounds, about 4 mm in depth and 8 mm in diameter, are inflicted, and the sample under investigation is applied over the wound. A plastic plate with a hole 8 mm in diameter is then placed over the test material in such a way that it provides a frame round the incised wound so that all blood has to pass through the samples. The time for control is observed; the end point being taken as the instant when bleeding is arrested as shown by the termination of blood flow through the sample.

The absorbability of the material is related to its solubility characteristics.

The foregoing and comparable materials prepared from different denier rayons have the following denier vs. solubility characteristics:

	Filament Denier Before Oxidation	% COOH in Oxidized Material	Time for Solution		
			1% NaOH	2.5% Na_2CO_3	3% $NaHCO_3$
EXAMPLE 1	1.6	19.6	45 sec.	4.4 min.	3.5 hrs.
EXAMPLE B	9	19.4	(insoluble) hydrated only	4.4 min.	5.0 hrs.

Example B was prepared in the same manner as Example 1 except that the denier and % COOH in the oxidised material differed as indicated above.

The solubility characteristics are measured by the time required to dissolve a 3×3 mm² piece of fabric in solutions of 1 per cent NaOH, 2.5 per cent Na_2CO_3 and 3 per cent $NaHCO_3$. These concentrations are found helpful in distinguishing differences between samples.

In clinical use, the 1 to 9 denier materials are absorbed uniformly and completely, with minimal foreign body reaction.

The procedure for determining stability of the material involves storing the samples thereof, under either sterile or non-sterile conditons, at the desired temperature.

Deterioration is measured by determining the amount of water soluble material in the stored samples. Samples to be tested are removed from storage and allowed to come to room temperature.

Approximately 75 mg. of the sample is placed in a one ounce glass vial filled with distilled water and is allowed to stand overnight (17 hours) in a room at a controlled temperature. The content is then filtered through a coarse fritted glass funnel. The filtrate and residue are transferred to tared aluminum weighing dishes and are evaporated to dryness on an electric hot plate. The dishes are then cooled and weighed. The per cent of soluble material is calculated by the following formula:

$$\frac{\text{mg. filtrate}}{\text{mg. filtrate} + \text{mg. residue}} \times 100 = \%\ \text{solubles}$$

Following this procedure the following results are obtained for the Example 1 material:

Temperature at which sample is left in distilled water	% water-soluble material in sample	
	Immediately after oxidation	After ageing for 3 months
70° F.	2.60	2.9
100	2.60	10.5

In a comparative run using cotton oxidized in known manner, e.g., by nitrogen dioxide gas, the following data is obtained:

Temperature at which sample is left in distilled water	% water-soluble material in sample	
	Immediately after oxidation	After ageing for 3 months
70° F.	12.7	11.4
100	12.7	30.4
120	12.7	52.0

As previously stated, the absorbability of the oxidised cellulose is related to its solubility characteristics, and is directly proportional to the percentage of the material which is soluble in water. The foregoing data indicates that material prepared in accordance with the invention contains one fourth or less as much soluble material as oxidised cellulose prepared in accordance with the prior art so that the Example 1 material shows about a 4-fold improvement over the conventional oxidized cotton as to stability.

EXAMPLE 2

Following the procedure of Example 1, but using 1 denier material, comparable results are obtained. The denier vs. solubility characteristics thereof are:

	Filament Denier Before Oxidation	% COOH in Oxidized Material	Time for Solution		
			1% NaOH	2.5% Na_2CO_3	3% $NaHCO_3$
EXAMPLE 2	1	19.8	43 sec.	4.3 min.	3.0 hrs.

EXAMPLE 3

Following the procedure of Example 1, but using 3 denier material, comparable results are obtained. The denier vs. solubility characteristics thereof are:

	Filament Denier Before Oxidation	% COOH in Oxidized Material	Time for Solution		
			1% NaOH	2.5% Na_2CO_3	3% $NaHCO_3$
EXAMPLE 3	3	19.4	161 sec.	24 min.	5.0 hrs.

The 3 to 9 denier materials represent operative modifications of the invention, but the lower deniers as set forth in the foregoing Examples are preferred.

A sample of the starting fabric analyzed by known procedures gives a cellulose D.P. (degree of polymerization) value of from 300 to 400. The method of analysis depends on the solution of the yarn in a cupriethylene-diamine (CED) solution — 1.0 molar with respect to copper and an ethylenediamine to copper ratio of 2.0 plus 0.05. The viscosities are determined in calibrated No. 100 Ostwald Fenske viscometers. The viscosity in centipoises is related to the degree of polymerization determined as described in Rosveare and Poore, *Ind. Eng. Chem. 45*, 2518 (1953).

This exceptionally low D.P. is an important feature for the material of the invention. The oxidation process provides the desired uniformly oxidized product without undue degradation, so that the product has adequate strength and physical stability, even after extended storage.

EXAMPLE 4

The starting material is rayon staple which has been carded. It is 100 per cent bright rayon essentially metal-free staple of a staple length of 1-9/16 inches and 1.5 denier chemically crimped. Such staple may be made by the method described in U.S. Patent No. 2,821,489.

The material is fastened to a perforated core and wound loosely around the core. The staple and core are secured in place in a glass or glas-lined reactor. The trichlorotrifluoroethane is charged into the reactor and the circulating pump, to circulate the fluid through the core, is started. Sufficient dinitrogen tetroxide is then added to the liquid to bring the dinitrogen tetroxide content up to 20 per cent of the liquid phase. The temperature of the liquid mixture is maintained at approximately 24°C. and the pumping continued for 15½ hours.

After this time the reaction is terminated by draining the reaction liquor from the reaction vessel and covering the oxidized fabric with carbon tetrachloride. The carbon tetrachloride is pumped through the fabric for 15 minutes, drained, and fresh carbon tetrachloride is added two more times and the fabric treated in similar fashion. After the carbon tetrachloride washes remove the bulk of the dinitrogen tetroxide, a 50 per cent water-isopropyl alcohol solution is added and pumped through the fabric. This is followed in similar manner by two fresh washes of the same mixture. Two final washes of 99 per cent isopropyl alcohol are then used to remove traces of water. The fabric is dried in a forced air oven at room temperature. Alternatively, trichlorotrifluoroethane is used in place of carbon tetrachloride.

After drying, the material is cut into appro-

priate sizes, packaged (i.e., in a container which is impervious to microorganisms, but pervious to the sterilizing agent, or one which is partly open and is closed after the sterilization step), and sterilized by heat and formaldehyde vapors.

A vacuum is drawn on the sterilizer and a temperature of 135°F. is maintained. A solution of 90 parts U.S.P. Formaldehyde Solution and 10 parts glycerin is heated in a connecting generator. This is introduced into the sterilizer, up to a sterilizng dose level. During the introduction the temperature of the load rises and is maintained at 160°F. for one hour. The sterilizer is then evacuated and the sterilized packages are removed.

The chemical analysis of the resulting product is:

Oxidized Rayon Staple	
% CH_2O	0.50
% COOH	19.1—20.3
% N_2	0.30
% Ash	0.028
pH Filtrate	3.5
Heavy Metals	2—2.5 parts per million

EXAMPLE 5

The procedure of Example 4 is repeated except that the starting material is 100 per cent bright rayon staple of a staple length of $1\frac{5}{16}$ inches and 1.5 denier chemically crimped, which has been carded and then needled into an interwoven mat.

The chemical analysis and the resulting product is:

Oxidized Rayon Needle Loom	
% CHOH	0.776
% COOH	19.1—21.2
% N_2	0.29
% Ash	0.146
pH of Filtrate	3.7
Heavy Metals	9 parts per million

This hemostatic activity is determined by the procedure described in relation to Example 1.

The absorbability of the material is related to its solubility characteristics.

The foregoing materials of Example 4 with the minor modification that they were prepared from the under-noted slightly different denier rayons have the following denier vs. solubility characteristics:

	Filament Denier Before Oxidation	% COOH in Oxidized Material	Time for Solution 1% NaOH	2.5% Na_2CO_3	3% $NaHCO_3$
EXAMPLE 4	1.6	19.6	45 sec.	4.4 min.	3.5 hrs.
EXAMPLE C	9	19.4	(insoluble) hydrated only	4.4 min.	5.0 hrs.

Example C was prepared in the same manner as Example 4 except that the denier and % COOH in the oxidised material differed as indicated above.

The solubility characteristics are measured by the time required to dissolve a 75 mg. pledget of intertangled fibres in solutions of 1 per cent NaOH, 2.5 per cent Na_2CO_3 and 3 per cent $NaHCO_3$. These concentrations are found helpful in distinguishing differences between samples.

In clinical use, the 1 to 9 denier materials are absorbed uniformly and completely, with minimal foreign body reaction.

Following the procedure previously set forth for determining deterioration the following results are obtained for the Example 4 material:

Temperature at which sample is left in distilled water	% water-soluble material in sample: Immediately after oxidation	After ageing for three months
70° F.	2.60	2.9
100	2.60	10.5

Using fibrous masses similar to Example 4 but differing in denier and using a filament denier of 1 and a filament denier of 3, Example 4 was repeated with solubility results in the NaOH, Na_2CO_3 and $NaHCO_3$ solutions already mentioned similar to those obtained in Examples 2 and 3 where the rayon fibres were in the form of knitted fabrics.

Comparable results to the materials made according to any of Examples 1—5 may be obtained with various modifications thereof, including the following.

A lower dinitrogen tetroxide concentration can be used over a longer period of time or at a higher temperature to obtain the same oxidation levels. Alternatively, other means of sterilization can be employed, such as ethylene oxide systems, use of its homologues, or irradiation techniques.

The filament (of a denier in the range of 1 to 9 and preferably 1 to 3) may be made up into multi-filament yarn and then into knitted fabric of comparable porosity or density, e.g. warp-knit, filling-knit, and circular knit.

These are preferred constructions, but where all of the advantages thereof are not necessary, woven fabrics of comparable density and porosity may be made from such filaments and yarns. In general, the porosity may be in the range of, or equivalent to, a fabric having 15 to 20 courses to the linear inch and 15 to 20 wales to the linear inch.

Although the invention has been described for purposes of illustration with reference to knit fabrics and masses of carded staple fiber composed of oxidized regenerated cellulose, it is equally applicable to the preparation of absorbable hemostats in any other form, as for example, absorbable hemostatic threads, sutures, knit or woven tubes for use as or in conjunction with surgical prostheses and the like which may also be prepared according to the invention.

The degree of polymerization of the cellulose may be about 230 or even lower but should not be in excess of about 400.

The use of oxidized regenerated cellulose gauze prepared as in Example I as an absorbable hemostat in surgical procedures has been investigated extensively.

Oxidized regenerated cellulose prepared in this way is inherently hemostatic. When exposed to whole human blood it is converted into a dark brown or black gelatinous mass, which appears to form, in effect, an artificially produced clot within the openings of the bleeding vessels and in the surrounding area. Hemostasis becomes complete in approximately one or two minutes. The material does not enter into the normal physiologic clotting mechanism per se, and for that reason is effective in controlling bleeding in many cases of hemophilia, thrombocytopenic purpura and other blood dyscrasiae.

Oxidized regenerated cellulose produced as described above has been intensively studied both experimentally and clinically to determine the rate and extent of its absorption in body tissue. Pieces of the knitted and carded fiber types, of uniform size weighing 75 mg. were implanted subcutaneously in rats by the Frantz-Lattes technique and the gross appearance of the subcutaneous implants and surrounding sites recorded. Seven days after implantation, the oxidized regenerated cellulose implants had the appearance of a soft gelatinous mass; tissue reaction being slight. At the end of fifteen days, the implanted material was observed to be completely absorbed with no evidence of inflammation. Necropsy studies in humans have been reported in whom the material was implanted in the course of various surgical procedures, and who died of causes not directly related to their surgery. In 10 such patients, autopsies were performed at intervals of from 1 to 77 days postoperatively. In the longer term specimens the fabric could not be identified grossly, although microscopically small shreds of debris could be detected in areas of subsiding tissue reaction. As a matter of record, no toxic or other untoward reaction has been observed in the course of either extensive animal or human use.

The absorbable hemostatic knitted fabric and carded fiber pads of the present invention have broad surgical applications. By helping to reduce the risk of uncontrollable hemorrhage, this new material extends the range of surgical procedures which may be undertaken with relatively greater safety. Complete absorption without tissue reaction raises the ratio of normal recoveries, particularly in difficult surgical procedures. The knitted fabric is particularly useful in general surgery for the control of capillary or venous bleeding or small arterial hemorrhage where conventional means of control are technically impractical. Such bleeding may occur in gall bladder and bile duct surgery, partial hepatectomy, resections or injuries of the pancreas, spleen, kidneys, prostate, bowel, breast, or thyroid and in amputations of the extremities. In well over 100 consecutive human cases ranging in age from two months to 77 years, the material was found to be effective and well accepted physiologically in such major procedures as liver biopsy, advanced malignancies, extensive thoracic and cardiovascular surgery, and general abdominal procedures including cholecystectomy and colectomy. In several instances the new hemostatic material was considered life-saving. In no instance was wound infection, toxic reaction or death attributed to the absorbable hemostats of the invention. Apparently the presence of local infection is not in itself a contraindication to the use of these materials although, needless to say, no obstruction to drainage should exist under such conditions. One investigator found no evidence

of untoward postoperative effect even in the presence of grossly contaminated wounds or leakage of infected urine.

In addition, owing to its toughness, the new hemostat lends itself very well indeed to tamponade of bleeding from solid viscera, when used as a bolster beneath mattress sutures. Reported cases include many types of urologic surgery in addition to prostatectomy, splenorenal shunts, pancreatomy, excision of acute aneurysm, and other major vascular procedures. Another investigator has recorded the use of these materials in a series of 100 patients in various surgical situations where rapid hemostasis was desirable. In 41 cholecystectomy cases, hemostasis was found to be excellent or good in all instances where the material was implanted in the gall bladder bed. In all instances, healing occurred without incident. The absorbable hemostat was also used in 34 hemorrhoidectomies with completely effective hemostasis. There is relatively little bulk to the material so that sphincteric spasm (and consequent pain) due to bulk per se (e.g., a petroleum jelly pack) was minimized. There is no need to remove the new hemostats manually as the material becomes jelly-like and is passed spontaneously in 2—3 days in the Sitz bath. Finally, as the material is reabsorbed by the body, there is no need to anticipate any foreign body granuloma formation as has been observed with other types of hemostatic packing. In more massive types of surgery, such as the resection of large intra-abdominal neoplasms, abdomino-perineal resections and vagotomies, it was found that persistent oozing could be effectively controlled with the new hemostats in all cases without any postoperative problems resulting from leaving the material in situ.

These materials have also been found to be extremely effective in controlling bleeding from the lacerated surface of the liver resulting from stab wounds of the abdomen. In referring to eight such cases an investigator has commented that all patients recovered and none required re-operation. There were no untoward results attributed to the use of the hemostat. In thirteen instances of abdominal stabbings, the material, in addition to being used in some cases to control bleeding from a traumatized viscus, was also used locally to control bleeding in the surface wound. All wounds healed *per primam*, and no side reactions were observed. The new absorbable hemostat also is useful as a primary dressing for donor sites. Several investigators have noted that when so used, primary bleeding is quickly controlled and potentially copious secondary ooze is prevented. As healing progresses, that portion of the hemostatic material which becomes wetted with blood gradually dissolves so that the dressing is easily removed without sticking or reactivation of bleeding at the time of removal (7—10 days). There is no delay in healing, so that not only is bleeding adequately controlled, but epithelization is completed normally. Somewhat the same considerations apply to the use of the new materials in the treatment of minor emergency wounds with loss of substance. When used as a primary dressing on such wounds, bleeding is quickly controlled, thus often avoiding the necessity of suturing or more extensive procedures. The dressing can subsequently be removed without sticking. In the light of the evidence presented, the new material has been found excellent for the prompt control of hemorrhage under emergency or less than ideal conditions such as may occur in accidental situations.

One of the most dramatic fields of usefulness for oxidized regenerated cellulose is found in cardiovascular surgery. Investigators have found the fabric type adjunctively useful in connection with the implantation of large textile grafts, including those of the abdominal aorta. Many such grafts leak or weep considerably, even when pre-clotted. Such seepage can be controlled by covering the graft with a layer or two of the oxidized regenerated cellulose gauze prior to release of the proximal and distal clamps. There is usually sufficient blood in the field to react with the gauze and form a closely adherent sheath-like clot about the graft which effectively prevents oozing when the clamps are released. When the flow has been re-established and all bleeding controlled, the fabric can either be removed or left in situ since absorption of the gauze has been shown to occur without constriction of the graft or other untoward incident.

Neurologic procedures offer an important field of usefulness for the carded fiber pads of oxidized regenerated cellulose in controlling punctate bleeding from the brain itself and for many other purposes. Oozing from the calvarium during prosthetic repair of a skull defect, for instance, is controlled simply by laying a pad over the under surface of the flap at the time it is turned back and then removing it on completion of the operation. Hemorrhage from the dura or brain tissue is controlled simply by applying a small pledget of the carded fiber to the bleeding point. It quickly adheres and is completely absorbed with no local reaction or neurologic irritation, making removal unnecessary.

Both the new absorbable hemostatic gauze fabric and carded fiber pads are well adapted to many otolaryngologic procedures. When uesd to control spontaneous nasal hemorrhage that requires packing, the material not only provides prompt hemostasis, but is easily removed after 12 to 24 hours without causing secondary hemorrhage. Other indications include: control of postoperative adenoid hemorrhage, postnasal packing, packing following radical mastoidectomy, submucous resection of the nasal septum, radical ethmoidectomy,

and control of the oozing which may occur during tonsillectomy. The material need not be left in place, but can usually be gently removed at the conclusion of the procedure without reinitiating bleeding. It should be emphasized however, that this is not a substitute for ligation of bleeding points wherever possible, since disregard of this point may lead to secondary hemorrhage.

The new absorbable hemostats find many applications in oral surgery. Bleeding problems are controlled following single or multiple tooth removal, alveolectomy, intermediate or secondary hemorrhage, impactions, biopsies and other procedures in the oral cavity. A strip of hemostatic material may be used on the ridge area of immediate dentures to prevent seepage into the denture. Inasmuch as the new materials achieve hemostasis by virtually providing an artificially produced clot, independent of normal blood-clotting mechanisms in the wound, it is extremely useful and often life-saving in the control of post-extraction or other operative bleeding in hemophilia, thrombocytopenic purpura and other blood dyscrasiae. The knitted fabric of the invention has been used in over 200 surgical procedures about the oral cavity and in the control of severe nosebleed. The investigator was as impressed with the ease of handling as he was with the superior hemostatic effect of the new oxidized regenerated cellulose materials. In the postoperative management of full mouth extractions, optimal results are achieved by opening up the material slightly to cover a greater surface area with a thin layer so that the gauze can be laid over the sockets lightly. It is not necessary or desirable to use large amounts for effective hemostasis. Indeed, excessive wadding may delay healing or cause other possible complications. Results were also excellent when the hemostats were used in excision of lesions in the mouth, on the tongue, and during other radical maxillo-facial procedures. Unless the material was misused, healing was always excelilent and uncomplicated. Best results were obtained when small amounts of the fabric were held gently over the bleeding surface.

In addition to use internally of the body, the material of the invention may be used externally in conjunction with a non-absorbable carrier, for example, a surgical pad or gauze, or the pad of an adhesive dressing. The material can be formed into a cover sheet which may, for example, be knitted or woven, placed over an absorbent dressing pad so that the cover sheet is brought into contact with a wound, whereby its hemostatic properties are utilised to control bleeding; alternatively a dressing pad or surgical swab, may be formed from fibres of the material of the invention and non-absorbable fibres, e.g. cotton.

WHAT WE CLAIM IS:—

1. A hemostatic material uniformly absorbable in the body formed of an oxidised regenerated cellulose of filament denier in the range of 1 to 9 and degree of polymerisation prior to oxidation of not substantially over 400 glucose units and containing 12 to 25 per cent COOH radical by weight.

2. A material according to claim 1 wherein the filament denier is in the range of about 1 to 3 and the oxidised regenerated cellulose contains 18 to 22 per cent COOH by weight.

3. A material according to claim 1 or 2 in the form of a fabric.

4. A material according to claim 3 in which said fabric is a knitted fabric.

5. A material according to claim 4 having a count of 12 to 30 wales and 12 to 30 courses to the linear inch.

6. A material according to claim 1 or 2 in the form of a frictionally interlocked mass of fibres.

7. A material according to claim 6 in which said fibres have been mechanically interlocked by needling.

8. A material according to any of the preceding claims which is sterile.

9. A hemostatic material as described in any of the foregoing Examples 1—5.

10. A hemostatic material constructed and arranged substantially as hereinbefore described.

11. A process for preparing a fibrous hemostatic material according to any of the preceding claims comprising oxidising regenerated cellulose by treating the regenerated cellulose with a solution of dinitrogen tetroxide in trichlorotrifluoroethane containing dinitrogen tetroxide to a COOH content of 12 to 25% by weight of the oxidised regenerated cellulose, washing the oxidised cellulose with carbon tetrachloride or trichlorotrifluoroethane until the fibrous material is substantially free of dinitrogen tetroxide, washing with aqueous isopropyl alcohol, washing with isopropyl alcohol to remove the water, and drying at room temperature.

12. A process according to claim 11 wherein the treatment is carried out at a temperature of 20°C—28°C. for a time between 14 and 18 hours.

13. A process according to claim 11 or 12 wherein the first washing step is carried out with 50% aqueous isopropyl alcohol, and the second washing step is carried out with 99% isopropyl alcohol.

14. A process according to any of claims 11 to 13 including the further step of enclosing the material in a container impervious to microorganisms but pervious to vapours and further to subjecting the material and the container to heat and chemical sterilising vapours until sterilised.

15. A process for preparing a fibrous hemostatic material substantially as hereinbefore described.

For the Applicants,
CARPMAELS & RANSFORD,
Chartered Patent Agents,
24, Southampton Buildings,
Chancery Lane, London, W.C.2.

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Fig. 1.

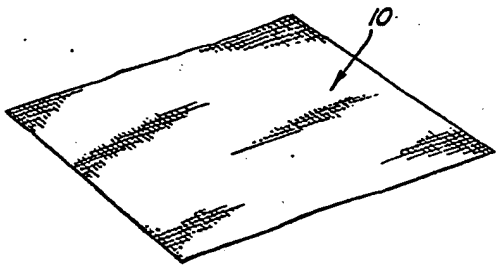
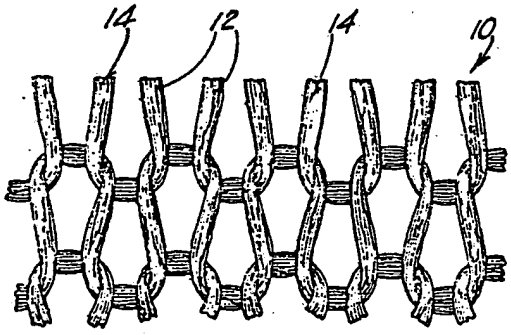


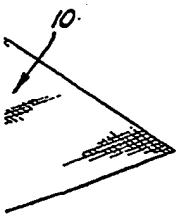
Fig. 2.

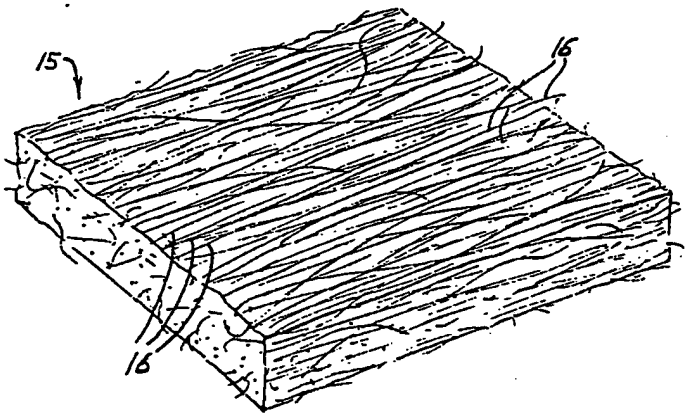


983073 COMPLETE SPECIFICATION

2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheets 1 & 2





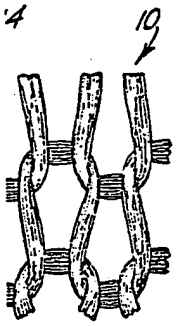


Fig.3.

983073 COMPLETE SPECIFICATION
2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheets 1 & 2

Fig.1.

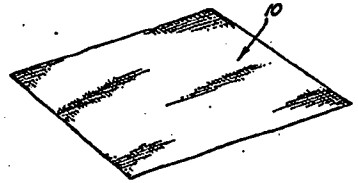
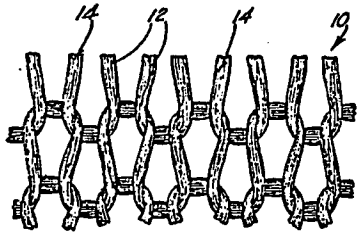


Fig.2.



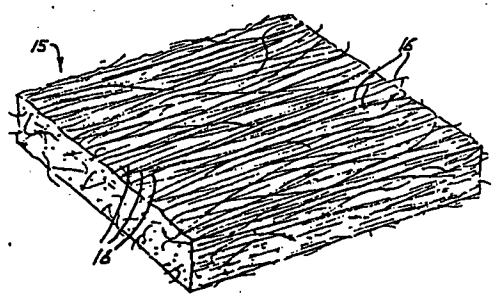


Fig.3.